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Microcontact structure for neuroprostheses for implantation on nerve tissue, and method therefor

The invention relates to an implantable microcontact structure for neuroprostheses for treating functional disorders of the nervous system for the purpose of reversible anchorage on nerve tissue.

Prior art

Several microcontact structures for partly implanted neuroprostheses are known whose spatial microcontact arrangement is fixed by a rigid, preshaped area, as, for example, in US Patent Specification 5,215,088.

Several microcontact structures for partially implanted neuroprostheses are known whose spatial microcontact arrangement is fixed by a partly elastic, flexible, preshaped area and that can alter as a result of the type of implant attachment and also as a result of passive matching to the tissue shape in the implant area, as in DE 4424753 A1.

The production of such a microcontact structure is disclosed, for example, in the following publication:

"Flexible, polyimide-based neural interfaces." Stieglitz, T., Beutel, H., Keller, R., Schuettler, M. and Meyer, J-U. Proceedings of the Seventh International Conference on Microelectronics for Neural, Fuzzy and Bio-Inspired Systems. IEEE Comput. Soc. 1999, pp. 112-19. Los Alamitos, CA, USA.

Disadvantages of the prior art

A disadvantage of the known microcontact structures is that no devices and methods are provided for an explantation of the microcontact structure.

Furthermore, the known microcontact structures do not have mechanisms that carry out the matching of the microcontact structure to the shape of the tissue to be contacted. It is therefore not possible to ensure that the spacing between the microelectrodes and the neurones to be stimulated in the nerve tissue is minimal

A further disadvantage of the known microcontact structures is that they do not have the possibility of spontaneous attachment of the microcontact structure to the nerve tissue.

A disadvantage of the currently designed or available microcontact structures for epiretinal optic prostheses is that they lack features that permit incorporation in the eye in spatially compressed shape and complicated surgical techniques are therefore necessary. This difficulty will intensify in the future because the spatial dimensions of the microcontact structures become greater with an increasing number of contacts.

Furthermore, the currently designed or available microcontact structures for epiretinal optic prostheses lack the possibility of covering the neurones of the retina that connect the region of sharpest vision with a high microcontact density since such neurones are situated in so-called parafoveal cell craters that are distinguished by a spatial crater structure.

The object of the present invention is therefore to eliminate these disadvantages and to disclose a

microcontact structure that can be introduced in compressed form into the body and can be reversibly anchored on the nerve tissue.
This object is achieved with a microcontact structure having the features of Claim 1.

The microcontact structure ensures a good contact or active connection to the nerve tissue since the implanted microcontact structure comprises subareas that are movable relative to one another that can be brought into at least two permanent preferred positions relative to one another and that, during the implantation, can be brought into a preferred position for the purpose of mechanical anchorage to the nerve tissue to be contacted and can also, during the explantation, can be brought out of one preferred position into another to release the anchorage.

Description of exemplary embodiments

Advantageous designs of the spatially adaptive microcontact structure and the associated methods are shown on the basis of Figures 1 to 4.

An advantageous design of the device of a spatially adaptive microcontact structure for neuroprostheses for implantation at nerve tissue embodies the feature that the microcontact structure can be produced as a planar, two-dimensional structure using current methods for producing microcontact structures, for example, on a silicon, silicone or polyimide base (see Figures 1-4), it can be folded or rolled very compactly in a second step for transportation purposes and can not only be unfolded planarly in a third step, but is folded or rolled into the third dimension (see Figures 1-3) so that a three-dimensional structure is produced.
An advantageous design of the microcontact structure embodies the feature that it is connected to further

modules of the neuroprosthesis via signal paths.

An advantageous design of the microcontact structure embodies the feature that it is used for implantation at mammalian muscle tissue or at blood vessels or at body organs, such as, for example, liver, spleen, lung or kidney and produces a unidirectional or bidirectional active connection locally at such a point.

An advantageous design of the microcontact structure embodies the feature that on the side adjacent to the nerve tissue after implantation, projecting structures, for example in the form of microelectrodes, sensors, cannulas or nails are provided that are essential for the mechanical anchorage of the microcontact structure.

An advantageous design of the microcontact structure embodies the feature that, for the purpose of conversion to a transportation position by folding, rolling or nesting of the mutually connected parts, segments or islands out of a preset planar basic position, spring elements, such as, for example, those after the fashion of spiral springs or helical springs and also elastic elements, such as, for example cushion-like microcontact structures filled with gases or liquids and enclosed with an elastic material and also, for example, porous, sponge-like microcontact structures are clamped in such a way that automatic restoration of the basic position is mainly prevented by a transport lock.

An advantageous design of the transport lock embodies the feature that the microcontact structure is held in the transportation position by a clamp that absorbs the forces or an envelope or pinning.

An advantageous design of the operation of the transport lock embodies the feature that the transport lock is released at the implantation point by using a suitable tool

so that conversion from the transportation to the basic position takes place as a controlled movement. In the case of a clamp, envelope or pin, this preferably takes place in that the forces are first absorbed by, for example, a tong-like tool, in that the transport lock is then removed with a further tool and in that the conversion to the basic position is then controlled with the aid of the tong-like tool.

In the case of an envelope brought about by temperature reduction or by a movement blockade produced by icing, the conversion from a locked transportation position to a basic position preferably takes place in that the mobility of its parts is restored by a controlled heat supply using a suitably shaped and controllable local heat source either as a separate tool or as an integrated element of the microcontact structure after positioning the microcontact structure at the implantation point.

An advantageous design of the microcontact structure embodies the feature, in the case of an envelope brought about by temperature reduction or a movement blockade produced by icing, the reconversion from an operating position to a basic position is preferably brought about in that the mobility of its parts is blocked by controlled heat removal using a suitably shaped and controllable local cold source (for example, a Peltier element) as an integrated element of the microcontact structure for the purpose of re-explantation.

A further advantageous design of the device of a spatially adaptive microcontact structure embodies the feature the structure, which is transported locked in a folded-up state and implanted, unfolds itself on removing the lock as a result of material properties and thereby assumes a previously impressed three-dimensional structure.

A further advantageous design of the device of a spatially adaptive microcontact structure embodies the feature, as a result of the self-unfolding, the structure assumes a shape in which it can engage with the tissue as a result of raised microcontacts (see Figure 3).

A further advantageous design of the device of a spatially adaptive microcontact structure embodies the feature, for the purpose of explantation, the shortened connections on the structure can be separated and the structure brings itself back, as a result of material properties, back into a planar state in which the engagements with the tissue are released.

A further advantageous design of the device of a spatially adaptive microcontact structure embodies the feature that the structure does not require any further attachment for the purpose of positionally stable implantation as a result of the engagement.

A further advantageous design of the method embodies the feature that the microcontact structure is based on a substrate of multilayer construction that has so-called memory properties in regard to the spatial arrangement of the microcontact structure. Figure 4 shows a section through an advantageous 4-layer microcontact structure in which the active connection between the microcontact structure and the nerve tissue is brought about by electrical stimulation. The layer adjacent to the nerve tissue to be stimulated is composed of the polymer P1 (polyimide) and contains penetrating electrodes made of the metal M (platinum), which forms the adjoining layer. There follows a further layer of the polymer P1 and a layer of the polymer P2 (polyurethane). The polymer P2 has the property of thermal expansion relative to P1 and the absorption of infrared radiation (IR) so that a defined volume expansion is brought about by irradiation with IR light.

In this way, the microcontact film is deformed at defined points by focused irradiation and matched to the nerve tissue. Furthermore, the polymer P2 has the property of carrying out structural transitions during electromagnetic irradiation from the ultraviolet wavelength range, said transitions resulting in contraction of the material. As a result, the deformation previously achieved by IR light or the opposite deformation is compensated for by means of focused UV treatment so that detachment of the microcontact structure from the nerve tissue takes place. In this way, the re-explantation of the microcontact film is initiated.

Patent Claims

1. Implantable microcontact structure for neuroprostheses, having a number of contact elements that are formed on at least one two-dimensional carrier, characterized in that the carrier has at least two regions that are movable relative to one another and that can assume at least two preferred positions, namely a basic position and an operating position.

2. Microcontact structure according to Claim 1, characterized in that the preferred positions of the microcontact structure can be fixed, interchanged or altered by external action before the implantation, during a surgical intervention or by external signals without surgical intervention.

3. Microcontact structure according to one of the preceding claims, characterized in that the spatial extension of the microcontact structure is minimized during the surgical transportation to the implant point by compacting, in particular by folding, nesting or rolling the parts that are movable relative to one another.

4. Microcontact structure according to one of the preceding claims, characterized in that the compacting of the microcontact structure provided for the surgical transportation can be released after positioning at the implantation point and brought to one of the preferred positions for the purpose of mechanical anchorage to nerve tissue.

5. Microcontact structure according to one of the preceding claims, characterized in that the compacting of the microcontact structure provided for the

surgical transportation remains locked by a transportation lock until said transportation lock is released by an external intervention.

6. Microcontact structure according to one of the preceding claims, characterized in that, after releasing the transport lock, the microcontact structure unfolds or opens out of the compact transportation shape in a controlled movement sequence into a preferred position suitable for preparing the mechanical anchorage as a result of releasing forces at the junctions between the parts of the microcontact structure, in particular as a result of spring forces, molecular conformation changes, pneumatic forces, hydraulic forces or/and electromagnetic forces.

7. Microcontact structure according to one of the preceding clams, characterized in that the interchange or the alteration of a preferred position of the microcontact structure for the purpose of its mechanical anchorage on the nerve tissue takes place in a measured manner in a time-controlled sequence with respect to movement and force as a result of externally defined action.

8. Microcontact structure according to one of the preceding claims, characterized in that the interchange or the alteration of a preferred position of the microcontact structure for the purpose of optimizing a contact or an active connection with the nerve tissue takes place in a measured manner in a time-controlled sequence with respect to movement and force as a result of an externally defined action.

9. Microcontact structure according to one of the preceding claims, characterized in that the external action according to Claims 7-8 takes place by means of

a surgical device or by means of transmitting signals to the microcontact structure, in particular by electromagnetic signals, light or ultrasound.

10. Microcontact structure according to one of the preceding claims, characterized in that the interchange of the preferred position chosen for the mechanical anchorage of the microcontact structure on the nerve tissue for the purpose of re-explantation takes place in a measured manner in a time-controlled sequence with respect to movement and force by an externally defined action.

11. Method for using a microcontact structure according to one of the preceding claims, characterized in that the microcontact structure is used, in particular, for retinal implantation for a retina implant, or for intracranial implantation on nerve tissue inside the skull, or for spinal implantation on nerve tissue of the spinal cord and its surroundings, or for implantation on peripheral nerves.